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SUPERMASSIVE BOSON STARS: PROSPECTS FOR OBSERVATIONAL DETECTION

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In a recent work (Torres, Capozziello and Lambiase, Physical Review D62, 104012 (2000)), it was shown that a supermassive boson star could provide an alternative model for the galactic center, usually assumed as a black hole. Here we comment on some of the possibilities to actually detect this object, and how can it be distinguished from the standard and other alternative models.

Although it is commonly believed that the center of the Galaxy is a supermassive black hole, it is not yet established on a firm observational basis. We have recently shown [1] that a supermassive boson or soliton star, if it exists at all, could well be at the center of some galaxies, including ours. These models can be in agreement current observations, and fit very well into dynamical and gravitational requirements. Their main features are:

1. The central object is highly relativistic, with a size comparable to (but slightly larger than) the Schwarzschild radius of a black hole of equal mass.

2. It has neither an event horizon nor a singularity, and after a physical radius is reached, the mass distribution exponentially decreases.

3. The particles that form the object interact between each other only gravitationally, in such a way that there is no solid surface to which falling particles can collide.

Then, how can we differentiate between this and the standard model? Without entering into the details, referring the interested reader to Ref. [1] and references therein, we shall mention some of the possibilities.

Firstly, one can make an in-depth *study of the properties of the accretion disk*. This gets complicated by the fact that the metric of boson stars is not analytically known. However, preliminary studies in the case of the simplest -black body behaving- accretion disk, have shown that the spectrum of the radiation emitted is modified, specially at high energies.

It has been already noted that *X-ray astronomy* can probe regions very close to the Schwarzschild radius. Recent results from the Japanese-US ASCA mission have revealed broadened iron lines, a feature that comes from regions which are

under strong gravitational influence. X-ray astronomy could be used to map out in detail the form of the potential well, and then as a discriminator. The NASA Constellation-X mission, to be launched in 2008, is optimized to study the iron K line feature discovered by ASCA.

Observations of very large baseline interferometry (VLBI) could also give the signature to discriminate among these models. Due to the phenomenon known as "shadowing", we might expect some diminishing of the intensity right in the center, this would be provided by effects upon relativistic orbits, however, this will not be as pronounced as if a black hole is present: for that case, many photons are really gone through the horizon and this deficit also shows up in the middle. Instead, if a boson star is there, some photons will traverse it radially, and the center region will not be as dark as in the black hole case. We also mention that the project ARISE (Advanced Radio Interferometry between Space and Earth) is going to use the technique of Space VLBI. It will study gravitational lenses at resolutions of tens of μarcsecs, yielding information on the possible existence (and signatures) of compact objects with masses between 10^3 and $10^6 M_\odot$.

If a particle with stellar mass is observed to spiral into a spinning object with a much larger mass and a radius comparable to its Schwarzschild length, from the emitted *gravitational waves*, one could obtain the lowest multipole moments. The black hole no-hair (or two-hair) theorem establishes that all moments are determined by its lowest two, the mass and angular momentum (assuming the charge equal to zero), for instance the mass quadrupole moment would give $M_2 = -L^2/M$. Should this not be so, the central object would not be a black hole, and as far as we know, the only remaining viable candidate would be a boson star. In this case, all multipole moments are determined by the boson star lowest three.

The formation of boson stars and black holes can be competitive processes. Then, it might well be that even if we discover that a black hole is in the center of the Galaxy, other galaxies could harbor non-baryonic centers. In the case of boson stars, only after the discovery of the boson mass spectrum we shall be able to determine a priori which galaxies could be modeled by such a center, if any. Observations of galactic centers could then suggest the existence of boson scalars much before than their discovery in particle physicists labs.

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References

1. D. F. Torres, S. Capozziello, and G. Lambiase, *Phys. Rev.* D **62**, 104012 (2000).